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A basic program is defined to investigate cyclic deformation, damage accumulation, and fatigue crack propagation (FCP) In the ordered Ni_3Al system as affected by composition, temperature, and environment. While this class of ordered alloys shows great promise for elevated temperature applications in jet and rocket engines, problems of brittleness and damage by hostile environments have been encountered in monotonic tensile deformation. The basic mechanisms of cyclic deformation and fatigue crack propagation have not been fully investigated; yet must be understood if these materials are to be used in advanced applications. Nickel Alloys. (KR)

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CYCLIC DEFORMATION, DAMAGE, AND EFFECTS OF ENVIRONMENT IN THE NI_3AL ORDERED ALLOY AT ELEVATED TEMPERATURES

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Program Manager: Dr. A. H. Rosenstein

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I. Program Overview

In this study, a basic program is defined to investigate cyclic deformation, damage accumulation, and fatigue crack propagation (FCP) in the ordered Ni_3Al system as affected by composition, temperature, and environment. While this class of ordered alloys shows great promise for elevated temperature applications in jet and rocket engines, problems of brittleness and damage by hostile environments have been encountered in monotonic tensile deformation. The basic mechanisms of cyclic deformation and fatigue crack propagation have not been fully investigated; yet they must be understood if these materials are to be used in advanced applications.

II. Program Status

A. Material Preparation

To investigate the role of boron in improving the ductility of this class of material two compositions were chosen, one which exhibits brittle behavior and the other which exhibits non-brittle behavior. Two other compositions, one subject to environmental influences and the other possessing relative insensitivity to environment will be used will be used to study the mechanisms of environmental embrittlement under conditions of cyclic loading.

Powder metallurgy techniques were used for the production of the above mentioned alloys by Homogeneous Metals, Inc. Each of the four alloys was produced by atomization of the melt resulting in power particles having identical chemistries. The powder alloys were then screened to +80-400 and extruded to produce 12' long bars approximately 2" in diameter which yielded nearly 200 lbs. of usable material of each of the four compositions. In addition, 50 lbs. of excess powder material for each of the four alloys was obtained which can be used in future investigations.

The compositions of the alloys are as follows;

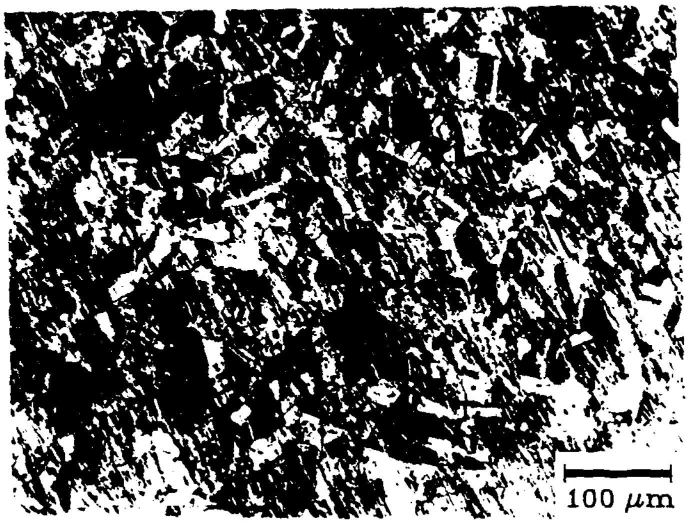
Alloy	Ni	Al	Atomic Percent Cr	B	C	S	N_2 (ppm)	O_2 (ppm)
A	Bal	12.91	0.0	.045	.0099	<.001	4	170
B	Bal	12.41	0.0	.048	.0066	<.001	5	72
C	Bal	10.26	8.0	.046	.0075	<.001	3	84
D	Bal	8.70	7.7	.046	.0060	<.001	3	84

In addition to the +80-400 powder, a small section attach to the end of each extrusion consisting of -400 mesh powder was produced providing an opportunity to fabricate a limited number of samples from very fine powder material.

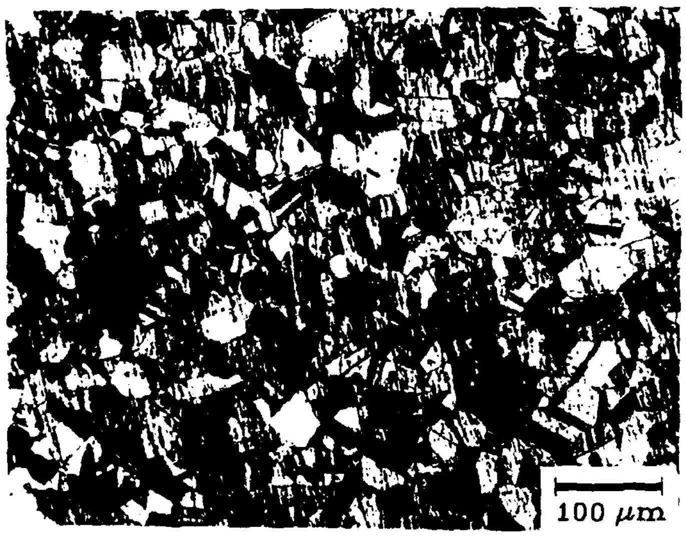
Optical metallagraphy of the extruded material reveals a fine grain material, ~80 μm, in both the transverse and longitudinal directions as shown in Fig. 1. Orientation studies utilizing the transmission electron microscope are currently underway to determine if any crystallographic texturing occured as the result of the extrusion process. The grains consist of both a dendritic and a lamellar structure with different lamellar spacings present within a given alloy.

Because Ni_3Al can exist over a range of compositions it is possible that the microstructure consists of a partially ordered solid solution whose composition varies in a systematic fashion. It is also possible that two phases are present, one being the strongly ordered Ni_3Al and the other a random solid solution of nickel. X-ray diffractometery studies of the alloys are underway to establish the degree of order in each alloy by measuring the intensity of the superlattice reflections. A typical structure as seen in the TEM is shown in Fig. 2.

Low cycle fatigue, Tensile, and FCP specimens will be machined from the extruded rods. Machining is to be performed by Mastersons Manufacturing and is expected to be completed by June 1988.



(a)



(b)

Figure 1 - Optical micrograph of specimen C, -80/+400 mesh along a) longitudinal and b) transverse direction.

Figure 2 - TEM micrograh of specimen C, -400 mesh showing low dislocation density and small grain size due to rapid cooling during atomization.

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